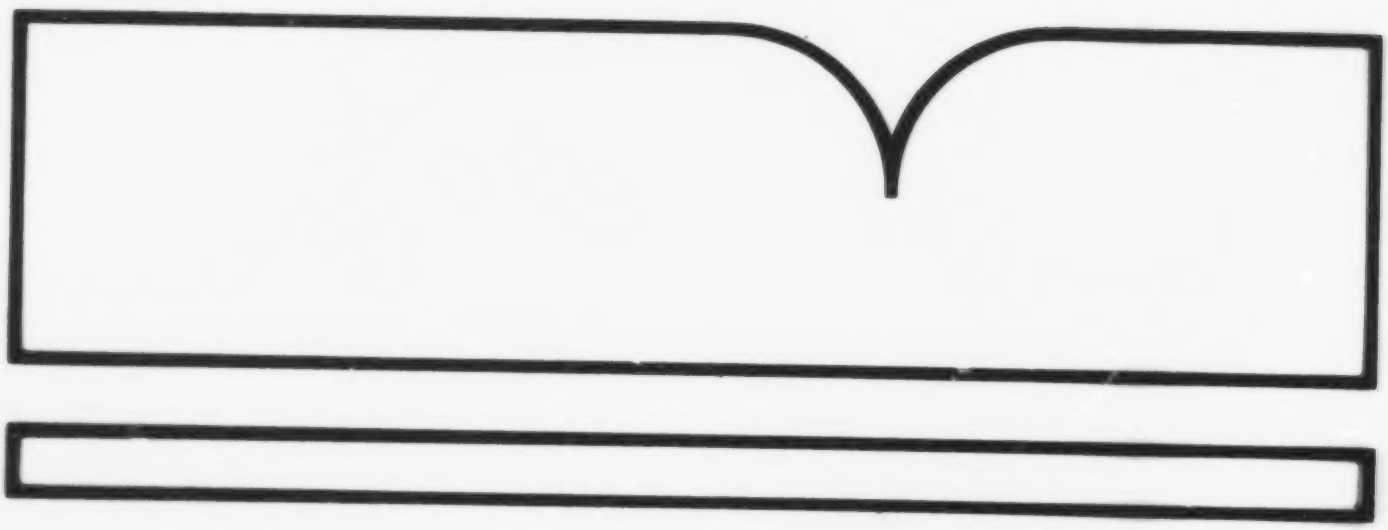
PB91-161471

Ambient Water Quality Criteria Document Addendum for DDT

(U.S.) Environmental Protection Agency, Cincinnati, OH

Sep 89



U.S. Department of Commerce
National Technical Information Service
NTIS

United States
Environmental Protection
Agency

FINAL DRAFT
ECAO-CIN-636
September, 1989

EPA

Research and Development

PB91-161471

AMBIENT WATER QUALITY CRITERIA DOCUMENT ADDENDUM FOR DDT

Prepared for

OFFICE OF WATER REGULATIONS
AND STANDARDS

Prepared by

Environmental Criteria and Assessment Office
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INFORMATION SERVICE
SPRINGFIELD, VA 22161

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1 PB91-161471	2. REPORT DATE September, 1988	3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE
Ambient Water Quality Criteria Document Addendum for DDT/DDD/DDE.

5. FUNDING NUMBERS

6. AUTHOR(S)
Criteria Branch/Office of Water Regulations & Standards

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. EPA/Office of Water Regulations & Standards
Criteria Branch (WH-585)
401 M Street SW
Washington, D.C. 20460

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Addendum to PB 81-117491

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Under the 1977 Clean Water Act, Congress mandated the U.S. Environmental Protection Agency to develop ambient water quality criteria for 129 priority Pollutants. These criteria were published in 1980. Under Section 304(a)(1) of the Clean Water Act as amended in 1987, the U.S. EPA is mandated to re-evaluate and update these criteria every five jears. These addenda represent an updated literature search current as of 1988, plus additional information form Agency files and Program Offices. This addendum is to update the existing Ambient Water Quality Criteria Document for DDT/DDD/DDE.

14. SUBJECT TERMS

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
unclassified	unclassified	unclassified	unlimited release

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PREFACE

Under the 1977 Clean Water Act, Congress mandated the U.S. Environmental Protection Agency to develop ambient water quality criteria for 129 priority pollutants. These criteria were published in 1980. Under Section 304(a)(1) of the Clean Water Act as amended in 1987, the U.S. EPA is mandated to re-evaluate and update these criteria every five years. These addenda represent an updated literature search current as of 1988, plus additional information from Agency files and Program Offices. The first draft of this addendum was prepared by Syracuse Research Corporation under contract no. 68-C8-0004.

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LIST OF ABBREVIATIONS

BCF	Bioconcentration factor
CRAVE	Carcinogen Risk Assessment Verification Endeavor
DDD	1,1'-(2,2-dichloroethylidene)-bis [4-chlorobenzene]
DDE	1,1'-(2,2-dichloroethenylidene)-bis[4-chlorobenzene]
DDT	1,1'-(2,2,2-trichloroethylidene)-bis[4-chlorobenzene]
LOAEL	Lowest-observed-adverse-effect level
NOAEL	No-observed-adverse-effect level
NOEL	No-observed-effect level
PEL	Permissible exposure limit
ppm	Parts per million
RfD	Reference dose
RQ	Reportable quantity
TLV	Threshold limit value
TWA	Time-weighted average

INTRODUCTION

Under Section 304(a)(1) of the Clean Water Act of 1977 as amended in 1987, the U.S. EPA is required to publish criteria for water quality accurately reflecting the latest scientific knowledge regarding the effects on health and welfare that may occur from the presence of pollutants in any body of water, including groundwater. In accordance with the 1977 act, Ambient Water Quality Criteria Documents (AWQCDs) were developed in 1980 for 65 toxic pollutants or classes of pollutants listed under Section 307(a)(1).

These addenda are intended to serve as an update of the original AWQCDs. The addenda provide the Agency with the latest scientific assessments of potential health hazards associated with these pollutants and serve as guidelines for modifying the current (1980) AWQCDs.

The human health criteria in these addenda are based on Agency verified risk assessment values when available. These values consist of reference doses (RfD) for those chemicals believed to be systemic toxicants (i.e., do not induce cancer) and cancer risk factors for those thought likely to cause cancer in humans. The verification process consists of a review and consensus of risk assessment values provided by an Agency workgroup consisting of scientists from each of the major Agency offices. Assessments for noncarcinogens are verified by the RfD workgroup and those for carcinogens are verified by the Carcinogen Risk Assessment Verification Endeavor (CRAVE) workgroup. If such values are not available, the criteria are based on the most recent Agency health assessment. In the absence of any appropriate Agency value, RfD values or cancer risk factors are derived by current Agency methods if adequate new data are available, and criteria are recommended based on the proposed RfD or risk factor.

The RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of the daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. The RfD is derived by dividing a NOAEL or LOAEL for subchronic or chronic exposure by standard uncertainty factor(s) times an additional uncertainty factor:

$$RfD = \frac{\text{NOAEL or LOAEL}}{UF(s) \times UF}$$

The standard uncertainty factors are applied to reflect the various types of data used to estimate RfDs. An uncertainty factor of 10 is used to account for variations in human sensitivity when extrapolating from valid human studies involving long-term exposure of average, healthy subjects. An additional 10-fold factor is used for each of the following: to extrapolate from long-term animal studies to the case of humans, to extrapolate from subchronic animal studies to chronic exposure, and to extrapolate from a LOAEL to a NOAEL. An additional uncertainty factor of >0-10 may be applied to reflect professional assessment of the uncertainties of the study and data base not explicitly addressed by the standard uncertainty factors (i.e., completeness of the overall data base). The default value for the additional uncertainty factor is 1.

In assessing the carcinogenic potential of a chemical, the U.S. EPA classifies the chemical into one of the following groups according to the degree of evidence in epidemiological studies and animal studies: Group A - Human Carcinogen; Group B - Probable Human Carcinogen [limited evidence in humans with or without sufficient evidence in animals (Group B1) or inadequate evidence in humans with sufficient evidence in animals (Group B2)]; Group C - Possible Human Carcinogen (limited evidence of carcinogenicity in animals in the absence of human data); Group D - Not Classifiable as to

Human Carcinogenicity (inadequate or no evidence); Group E - Evidence of Noncarcinogenicity for Humans. Quantitative carcinogenic risk assessments are performed for chemicals in Groups A and B, and on a case-by-case basis for chemicals in Group C. Upper-bound cancer unit risks (slope values) are estimated through the use of mathematical extrapolation models. Most commonly for animal data, the linearized multistage model with a 95% upper confidence limit is used to provide a low-dose estimate of cancer risk. The cancer risk is characterized as an upper-limit estimate (i.e., the true risk to humans, while not identifiable, is not likely to exceed the upper-limit estimate and in fact may be lower). Alternative risk models to the multistage model, such as the one-hit, Weibull, Logit or Probit model, are available and may be used when the evidence indicates that they may be more appropriate. In the absence of such evidence, the Agency recommends the linearized multistage model to provide consistency of approach and an upper-bound on the potential carcinogenic risk. In the case where human data are used for quantitative risk assessment, an upper-bound estimate rather than a 95% upper-bound estimate is used when low-dose linearity is assumed.

In the development of this Addendum to the AWQCD on DDT, recent Agency assessments have been consulted. A computerized literature search was conducted to cover studies published more recently than the latest Agency assessment (i.e., published in 1987 to 1988). New key studies have been evaluated.

REVIEW OF NEW DATA

Toxicologic/Carcinogenic Effects

The AWQCD (U.S. EPA, 1980) addressed DDT and its metabolites, DDD and DDE, but derived ambient water quality criteria only for DDT. Since the publication of the U.S. EPA (1980) document, the U.S. EPA's Carcinogen Assessment Group (U.S. EPA, 1986) has derived separate cancer potency estimates for oral exposure to DDT, DDD and DDE that have subsequently been verified (U.S. EPA, 1987a,b,c).

The following six studies were considered by the U.S. EPA (1986, 1987a) as the basis for derivation and verification of a cancer potency factor for DDT: Terracini et al. (1973), Turusov et al. (1973), Thorpe and Walker (1973), Tomatis and Turusov (1975), Rossi et al. (1977) and Cabral et al. (1982). The studies by Terracini et al. (1973), Turusov et al. (1973), Thorpe and Walker (1973) and Rossi et al. (1977) were discussed by U.S. EPA (1980) and will not be discussed here. The remaining studies are reviewed below.

Cabral et al. (1982) treated 6- to 7-week-old MRC Porton rats (Wistar-derived) for life with technical grade DDT (78.9% p,p'-DDT; 0.6% p,p'-DDD; 16.7% o,p'-DDT; 1.6% p'-DDT; 0.1% o,p'-DDD; 0.2% o,p'-DDE; unknown, 1.9%) dissolved in 3% olive oil and mixed into the diet. Rats were divided into four groups. One group (30/sex) received 125 ppm DDT (6/mg/kg/day), a second group (30/sex) was given 250 ppm DDT (12 mg/kg/day), a third group (38/sex) was fed 500 ppm DDT (24 mg/kg/day) and a fourth group (38/sex) served as the control. The total duration of the treatment was 144 weeks, at which time the survivors were sacrificed. DDT exposure did not modify the survival rate of rats of either sex. Both treated and control groups showed high incidences of liver-cell, pituitary, thyroid, mammary, and skin

tumors, but no dose-response relationship was observed regarding the total number of rats with tumors. Treated females, however, had a significant ($p<0.001$) dose-related increase in liver cell tumors compared with treated males and the control group. These tumors did not produce metastases in other tissues nor did they appear to be locally invasive.

In the study by Tomatis and Turusov (1975), CF-1 mice were fed diets containing 0 or 200 ppm DDT for 15 or 30 weeks and observed for 65, 95 or 120 weeks before sacrifice. The primary finding in this study was that only the incidence of benign liver tumors was increased. Longer exposure times produced larger tumors. Liver cell tumors did not show regression even when experimental treatment was discontinued. Liver tumors appeared earlier in control or treated males than in females. U.S. EPA (1986) concluded that DDT stimulates a carcinogenic mechanism already present in males, whereas females respond to DDT with de novo formation of tumors.

The three studies reviewed by the U.S. EPA (1986, 1987b,c) for derivation and verification of oral cancer potency estimates for DDD and DDE are Tomatis et al. (1974), NCI (1978) and Rossi et al. (1983). The studies by Tomatis et al. (1974) and NCI (1978) have been reviewed in U.S. EPA (1980) and are not reviewed here. Rossi et al. (1983) studied the effects of exposing 8-week-old Syrian golden hamsters for life to DDE (99%, dissolved in olive oil) at two dosage levels in the diet. A group of 45 females and 47 males received 500 ppm DDE; a second group of 43 females and 40 males was given 1000 ppm DDE; a third group of 46 females and 45 males was used as control and a fourth group (48/sex) received 1000 ppm DDT. Hamsters were treated until they reached 128 weeks of age, at which time the survivors were sacrificed and a gross and microscopic examination of all organs was performed. On the average, animals in the treated groups lived longer than

those in the control group, with males outliving females. In addition, in DDE-treated groups a dose-related delay in mean body weight gain was seen when compared with controls. The percentage of animals that developed tumors at all sites was similar in treated and control groups. A statistically significant ($p<0.05$) increased incidence of liver neoplastic nodules, however, appeared late in life in DDE-treated male and female hamsters and in DDT-treated females, but not in controls or in DDT-treated males. The response in DDE-treated hamsters was not dose-related. Also, the incidence of adrenocortical adenomas, spontaneous in Syrian golden hamsters, was greater than expected in all treated groups.

Two recent reports were located in the literature regarding the subchronic effects of DDT on the immune system of mice (Banerjee, 1987a) and rats (Banerjee, 1987b). Male albino mice (Hissar strain, 18-20 g), in groups of 12-15, were given diets containing 0, 20, 50 or 100 ppm DDT for 3-12 weeks. No clinical signs of toxicity were seen, but the humoral immune response to a T-independent antigen was significantly supressed. Groups of 10-12 Wistar male rats (85-90 g) were fed diets containing 0, 20, 50 or 100 ppm DDT for 8-22 weeks. Rats did not develop toxic signs, but DDT caused a significant decrease in serum antibody titer to tetanus toxoid in a dose-time-dependent manner.

No pertinent new data regarding carcinogenicity in humans from oral exposure to DDT or its metabolites DDE and DDD were located in the available literature.

Based on the results obtained from animal studies, DDT, DDD and DDE have been classified in U.S. EPA Group B2 - probable human carcinogen (U.S. EPA, 1986, 1987a,b,c).

Bioconcentration Factor (BCF)

Pertinent new information concerning the bioconcentration factors for DDT, DDD and DDE is currently undergoing Agency review. Until this review is completed the previously estimated weighted average BCF for DDT of 53,600 (U.S. EPA, 1980) can be adopted as the BCF for DDD and DDE.

QUANTIFICATION OF EFFECTS

Ambient water quality criteria of 0.24, 0.024 and 0.0024 ng/ℓ, corresponding to lifetime increased cancer risk levels of 10^{-5}, 10^{-6} and 10^{-7}, respectively, were derived for DDT (U.S. EPA, 1980), by assuming a daily intake of 2 ℓ of water and 6.5 g of fish and shellfish with a BCF of 53,600, by a 70 kg human. Because of the large BCF, the same criteria apply for consumption of fish and shellfish alone. These criteria are based on a q_1^* for DDT of 8.422 $(mg/kg/day)^{-1}$ derived from the incidence of total tumors in a 5-generation dietary study in mice (Tarjan and Kemeny, 1969).

More recently, the U.S. EPA (1986, 1987a) reviewed 25 animal carcinogenicity assays for DDT. Nine feeding studies, including two multigeneration studies have been conducted in mice with only one study (NCI, 1978) showing no indication of DDT tumorigenicity. Both heptacellular adenomas and carcinomas were observed in six studies and lung tumors were observed in the remaining two mouse studies. Studies in rats have shown an increase in benign liver tumors. In hamsters, exposure to DDT did not result in increased incidence of tumors. However, unlike mice, rats and humans, hamsters accumulate DDT in tissues but do not metabolize it to DDD or DDE.

A slope factor of 0.34 $(mg/kg/day)^{-1}$ for oral exposure to DDT was derived (U.S. EPA, 1986) and verified (U.S. EPA, 1987a), based on five studies on DDT (Terracini et al., 1973; Turusov et al., 1973; Thorpe and Walker, 1973; Tomatis and Turusov, 1975; Rossi et al., 1977; Cabral et al., 1982). This slope factor represents the geometric mean of the potency estimates based on the incidence of liver tumors in male and female mice and rats.

An increased incidence of liver tumors was seen in two species at three sites in mice and rats exposed to DDD but only the liver site was used to compute the oral quantitative estimate. A slope factor of 0.24 $(mg/kg/day)^{-1}$ was derived (U.S. EPA, 1986) and verified (U.S. EPA, 1987b) for DDD, based on the study by Tomatis et al. (1974). An increased incidence of liver tumors including carcinomas was observed in two strains of mice and in hamsters and an increased incidence of thyroid tumors in female rats fed DDE. The slope factor of 0.34 $(mg/kg/day)^{-1}$ for DDE derived by U.S. EPA (1986) and verified by U.S. EPA (1987c), is the geometric mean of six slope factors computed from incidence data for both males and females from the following studies (Tomatis et al., 1974; NCI, 1978; Rossi et al., 1983) (see previous section). The derivation of new cancer potency estimates permits the calculation of revised ambient water quality criteria for DDT and new criteria for DDD and DDE. Using the verified slope factor of 0.34 $(mg/kg/day)^{-1}$, and assuming a 70 kg body weight and a daily intake of 2 ℓ of water and 6.5 g of fish and shellfish with a BCF for DDT of 53,600, the criteria for DDT in ambient water are as follows:

Exposure Assumptions (per day)	Risk Levels and Corresponding Criteria (ng/ℓ)				
	0	10^{-7}	10^{-6}	10^{-5}	10^{-4}
2 ℓ of drinking water and consumption of 6.5 g of fish and shellfish	0	0.059	0.59	5.9	59.0
Consumption of fish and and shellfish only	0	0.059	0.59	5.9	59.0

Because the slope factor and BCF for DDE are identical to those for DDT, the above criteria calculated for DDT also apply to DDE.

Using the verified slope factor of 0.24 $(mg/kg/day)^{-1}$, and assuming a 70 kg body weight and a daily intake of 2 ℓ of water and 6.5 g of fish and shellfish with a BCF for DDD of 53,600, the criteria for DDD in ambient water are as follows:

Exposure Assumptions (per day)	Risk Levels and Corresponding Criteria (ng/ℓ)				
	0	10^{-7}	10^{-6}	10^{-5}	10^{-4}
2 ℓ of drinking water and consumption of 6.5 g of fish and shellfish	0	0.083	0.83	8.3	83
Consumption of fish and shellfish only	0	0.084	0.84	8.4	84

EXISTING STANDARDS AND CRITERIA

The WHO (1984) guideline for DDT in drinking water is 1 µg/ℓ.

The verified chronic oral RfD for exposure to DDT is 0.0005 mg/kg/day (U.S. EPA, 1985).

An RQ of 1 pound is proposed for DDT, based on aquatic toxicity (U.S. EPA, 1988).

The ACGIH TLV-TWA is 1 mg/m³ (ACGIH, 1987) and is designed to protect against acute toxicity and prevent significant accumulation in body stores (ACGIH, 1986). The OSHA PEL is the same as the ACGIH TLV-TWA (OSHA, 1985).

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